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(54) **LOCALIZATION SERVICES IN OPTICAL FIBER-BASED DISTRIBUTED COMMUNICATIONS COMPONENTS AND SYSTEMS, AND RELATED METHODS**

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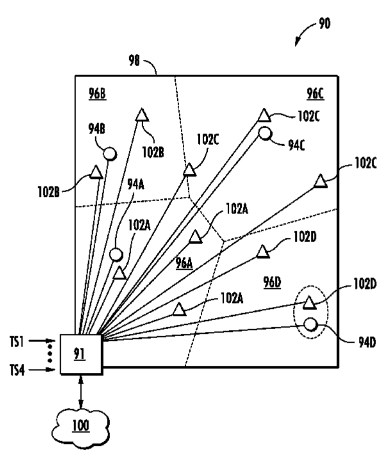
(57) **ABSTRACT**

Optical fiber-based distributed communications components and systems, and related methods to provide localization services for client devices are disclosed. The localization services allow the providing and/or determination of the location of client devices in communication with a component or components of the optical fiber-based distributed communications system. The location of client devices can be provided and/or determined based on knowledge of the location of the component or components in the optical fiber-based distributed communications system in communication with the client device. This information can be used to determine or provide a more precise area of location or area of location for client devices. The optical fiber-based distributed communications components and systems, and related methods disclosed herein may be well-suited for indoor environments where other methods of providing and/or determining location of client devices may be obstructed or not possible due to the indoor environment.

21 Claims, 12 Drawing Sheets



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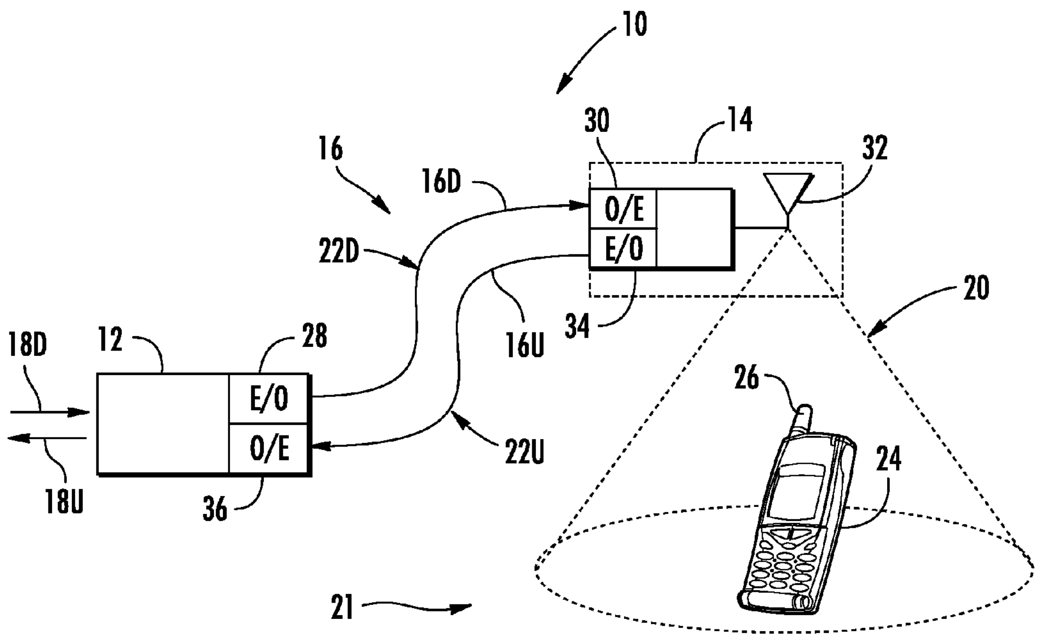
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16D
30
14
32
O/E
E/O
22D
20
34
16U
18D
12
28
E/O
O/E
26
22U
24
18U
36
21

FIG. 1

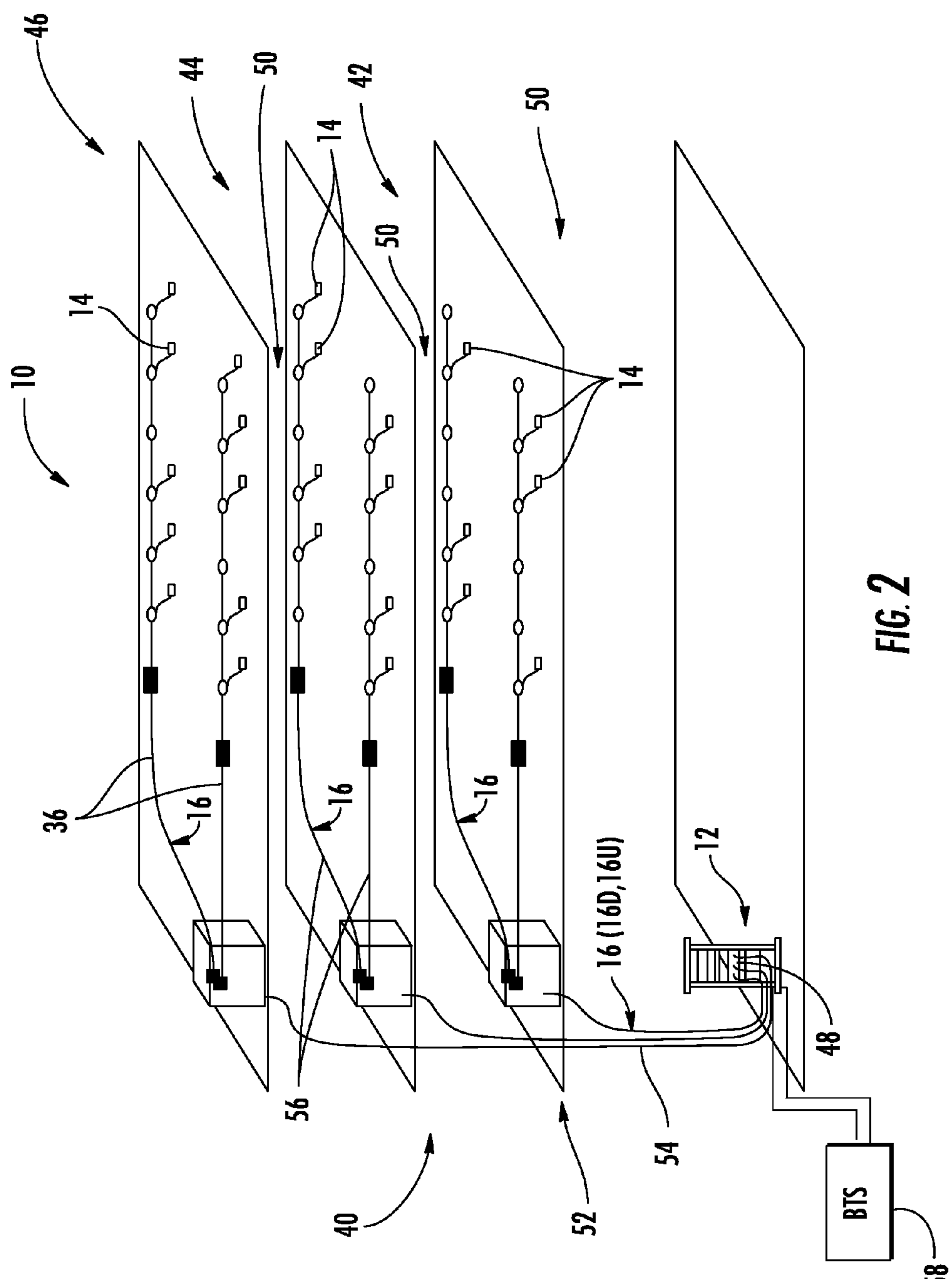

46
44
50
42
14
50
10
14
14
36
16
16
16
12
16 (16D,16U)
48
56
54
40
52
BTS
58

FIG. 2

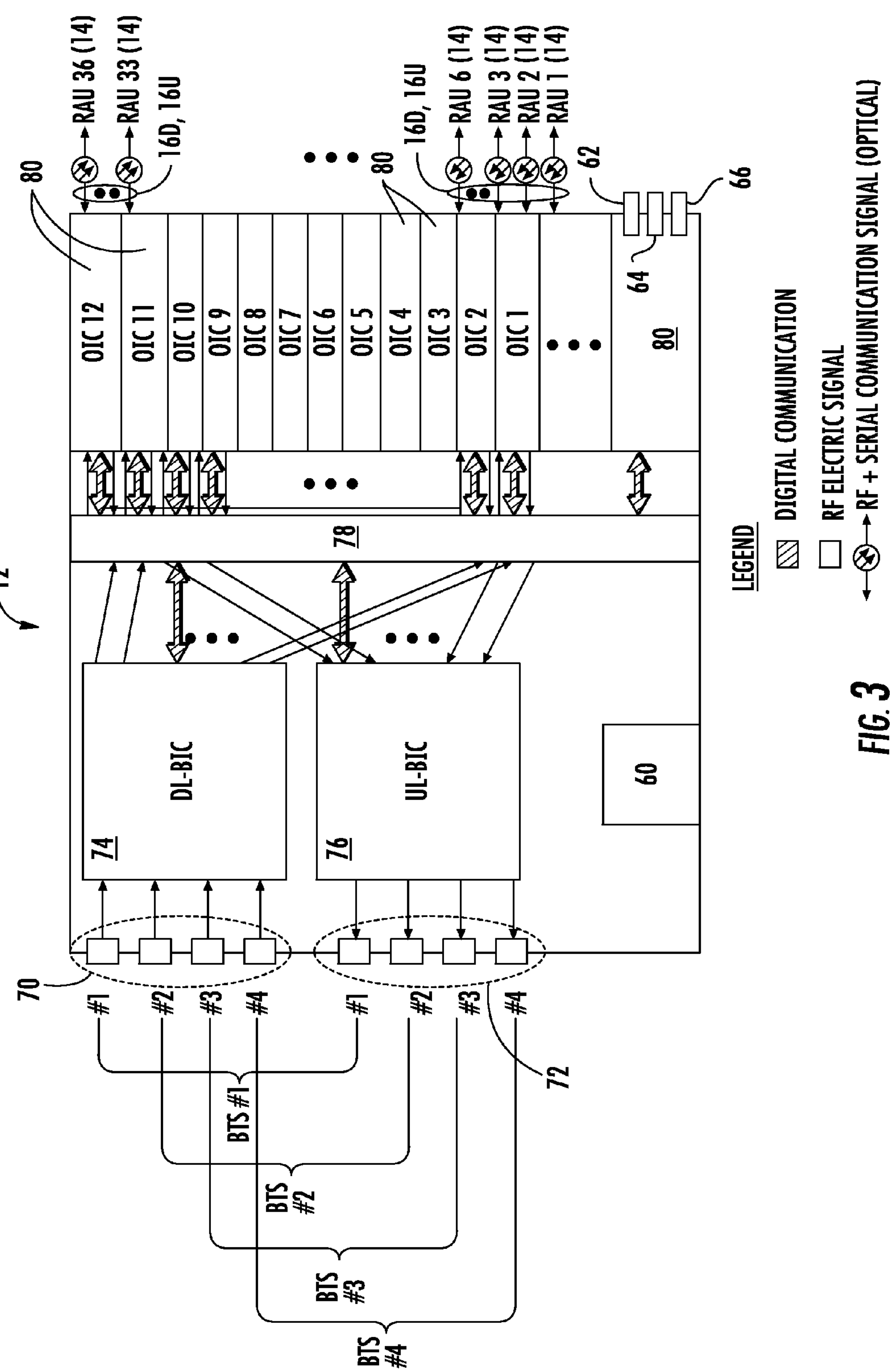
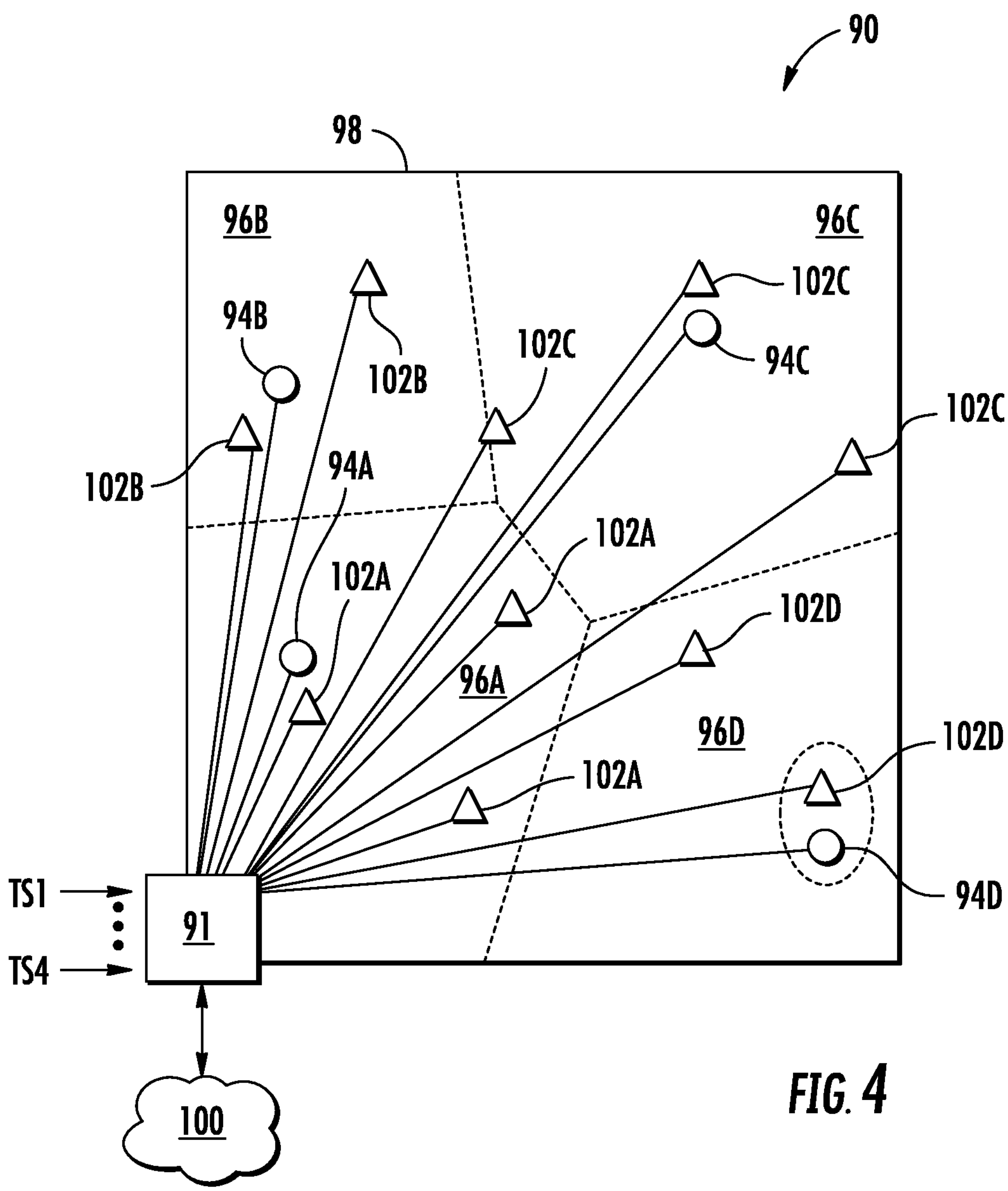

12
RAU 36 (14)
RAU 33 (14)
16D, 16U
RAU 6 (14)
RAU 3 (14)
RAU 2 (14)
RAU 1 (14)
80
62
66
64
OIC 12
OIC 11
OIC 10
OIC 9
OIC 8
OIC 7
OIC 6
OIC 5
OIC 4
OIC 3
OIC 2
OIC 1
78
DL-BIC
74
UL-BIC
76
60
70
72
#1
#2
#3
#4
BTS #1
BTS #2
BTS #3
BTS #4
LEGEND
DIGITAL COMMUNICATION
RF ELECTRIC SIGNAL
RF + SERIAL COMMUNICATION SIGNAL (OPTICAL)

FIG. 3



90
98
96B
96C
102C
94B
102B
102C
94C
102C
102B
94A
102A
102A
102D
96A
96D
102D
102A
TS1
91
94D
TS4
100

FIG. 4

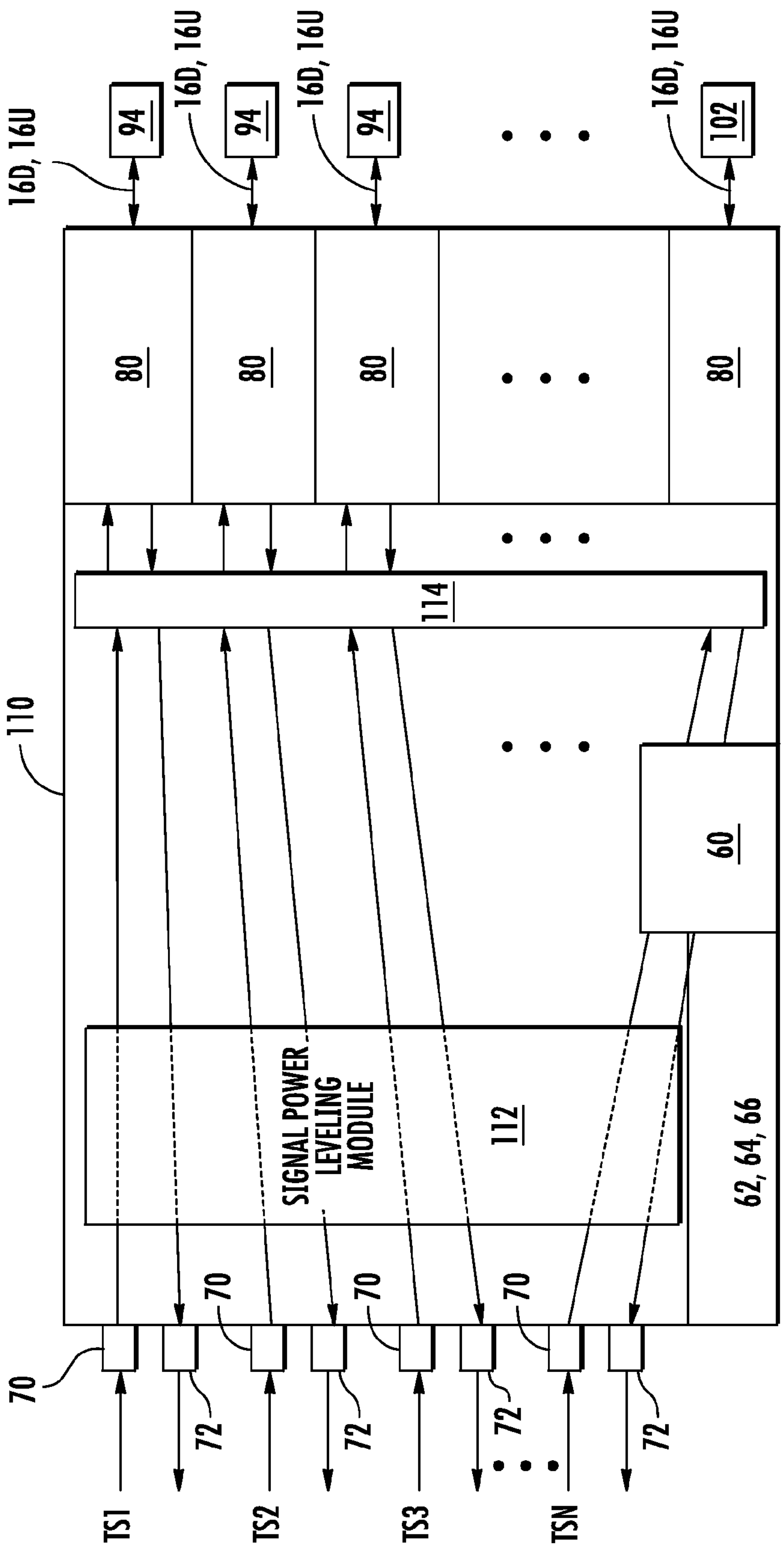
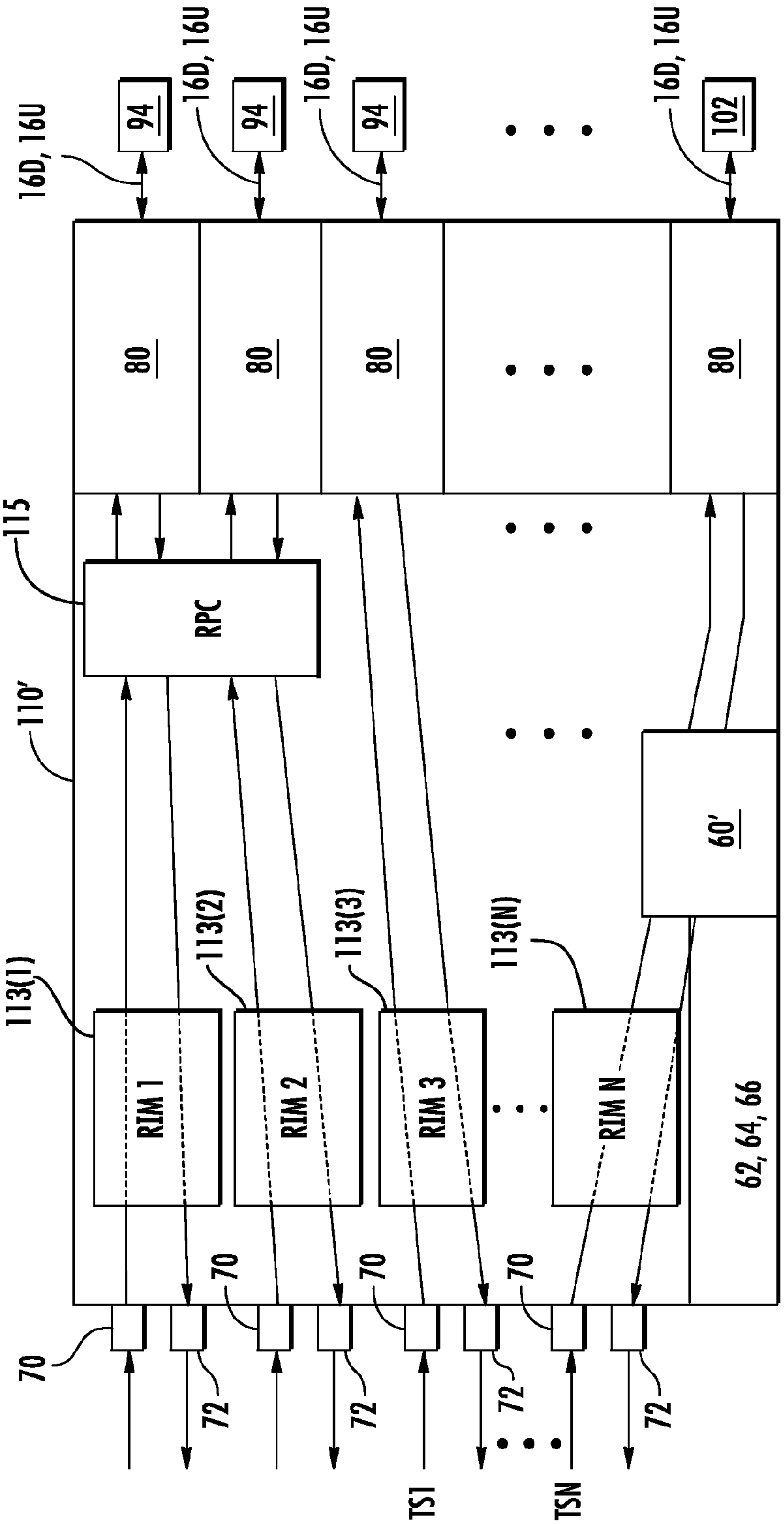
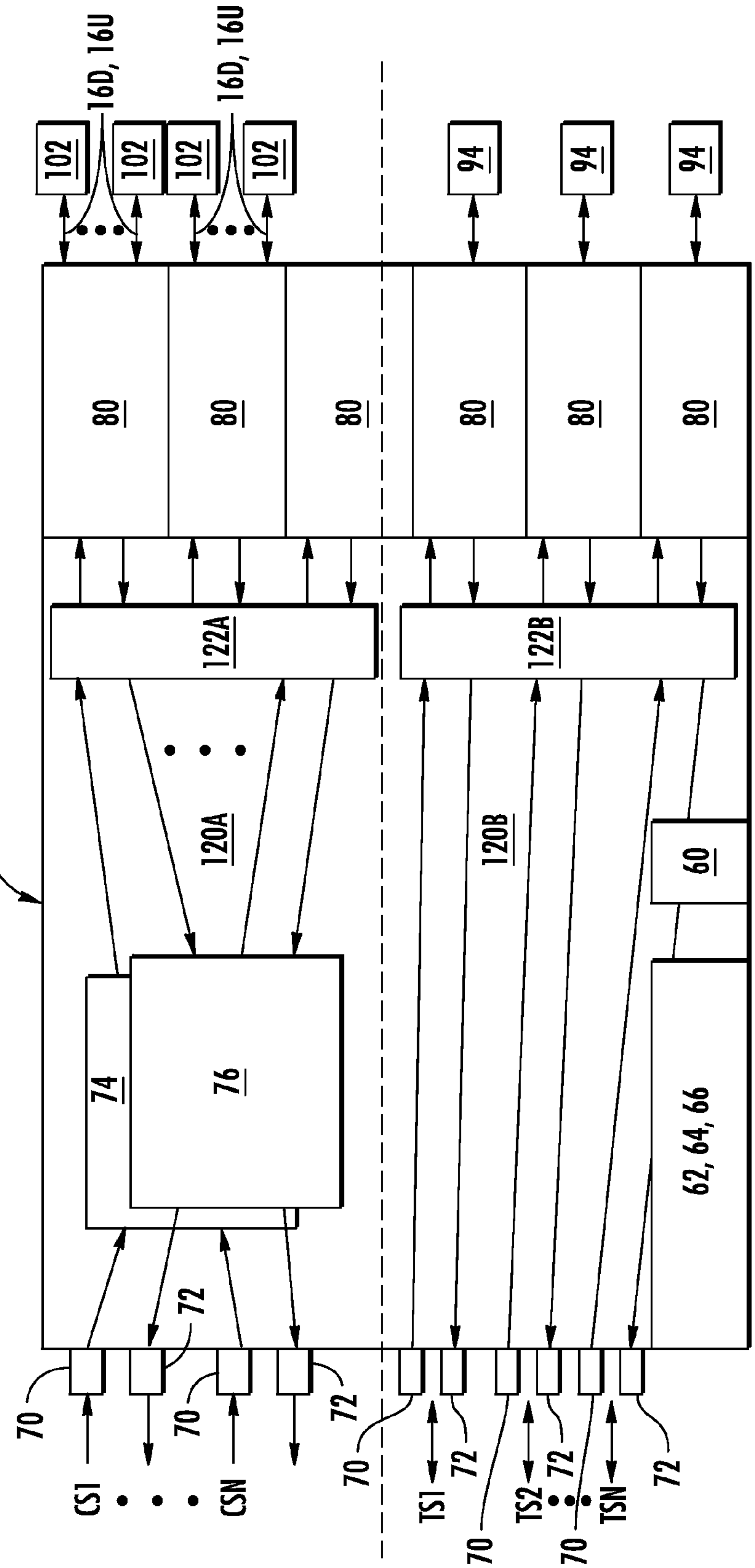

16D, 16U
94
16D, 16U
94
16D, 16U
94
16D, 16U
102
80
80
80
80
114
110
60
SIGNAL POWER LEVELING MODULE
112
62, 64, 66
70
72
TS1
TS2
TS3
TSN

FIG. 5A



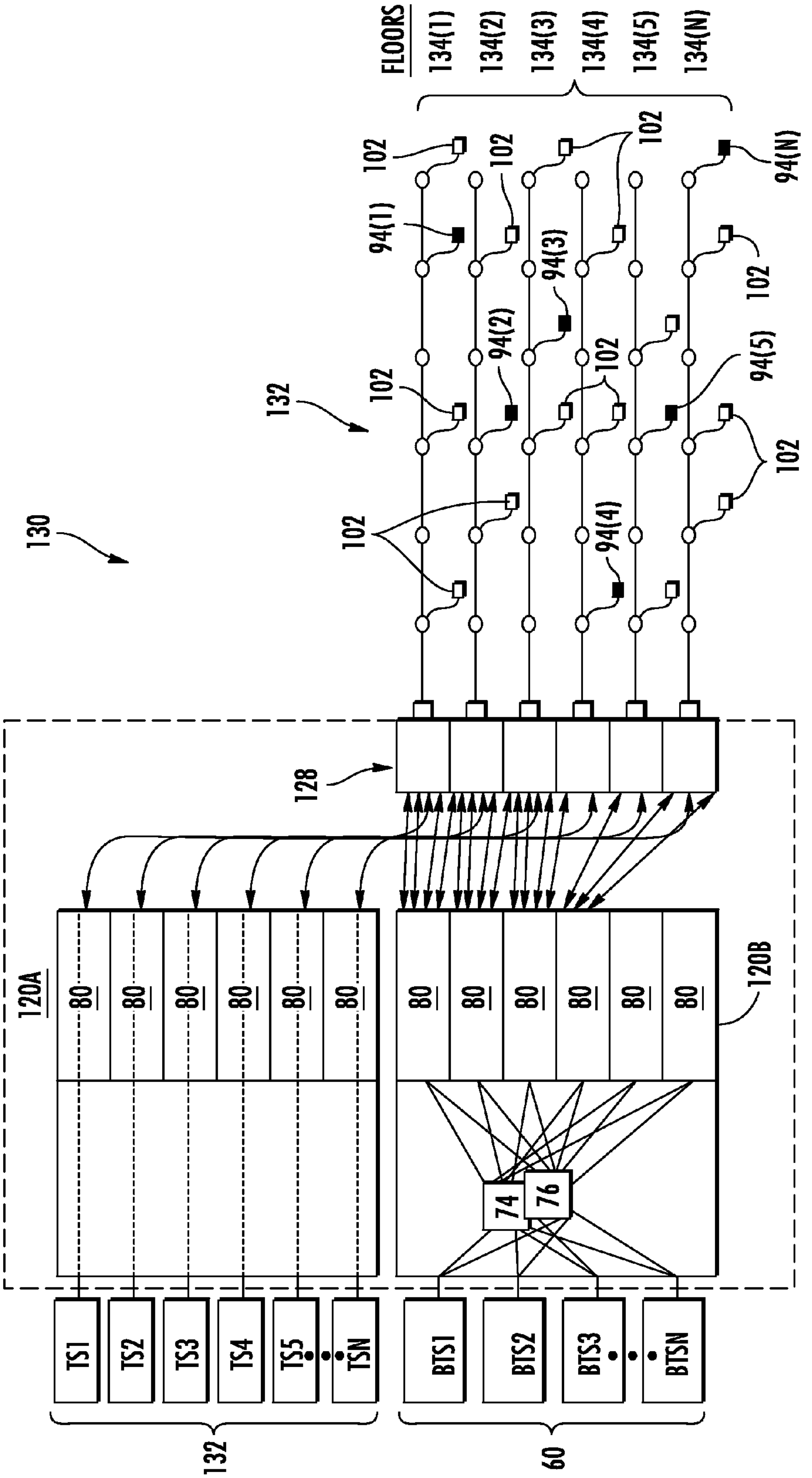
16D, 16U
94
102
80
115
RPC
110′
113(1)
113(2)
113(3)
113(N)
RIM 1
RIM 2
RIM 3
RIM N
60′
62, 64, 66
70
72
TS1
TSN

FIG. 5B



16D, 16U
16D, 16U
102
102
102
102
94
94
94
80
80
80
80
80
80
122A
122B
120
120A
120B
60
74
76
62, 64, 66
70
72
70
72
70
72
70
72
70
72
CS1
CSN
TS1
TS2
TSN

FIG. 6



130
132
FLOORS
134(1)
134(2)
134(3)
134(4)
134(5)
134(N)
102
94(1)
94(2)
94(3)
94(4)
94(5)
94(N)
128
120A
120B
80
74
76
TS1
TS2
TS3
TS4
TS5
TSN
BTS1
BTS2
BTS3
BTSN
132
60

FIG. 7

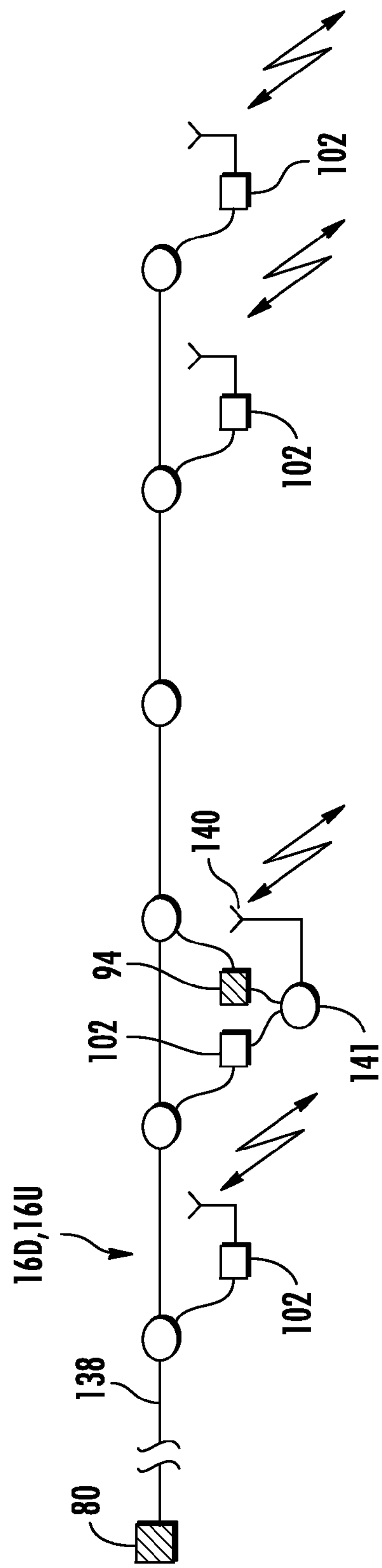


FIG. 8

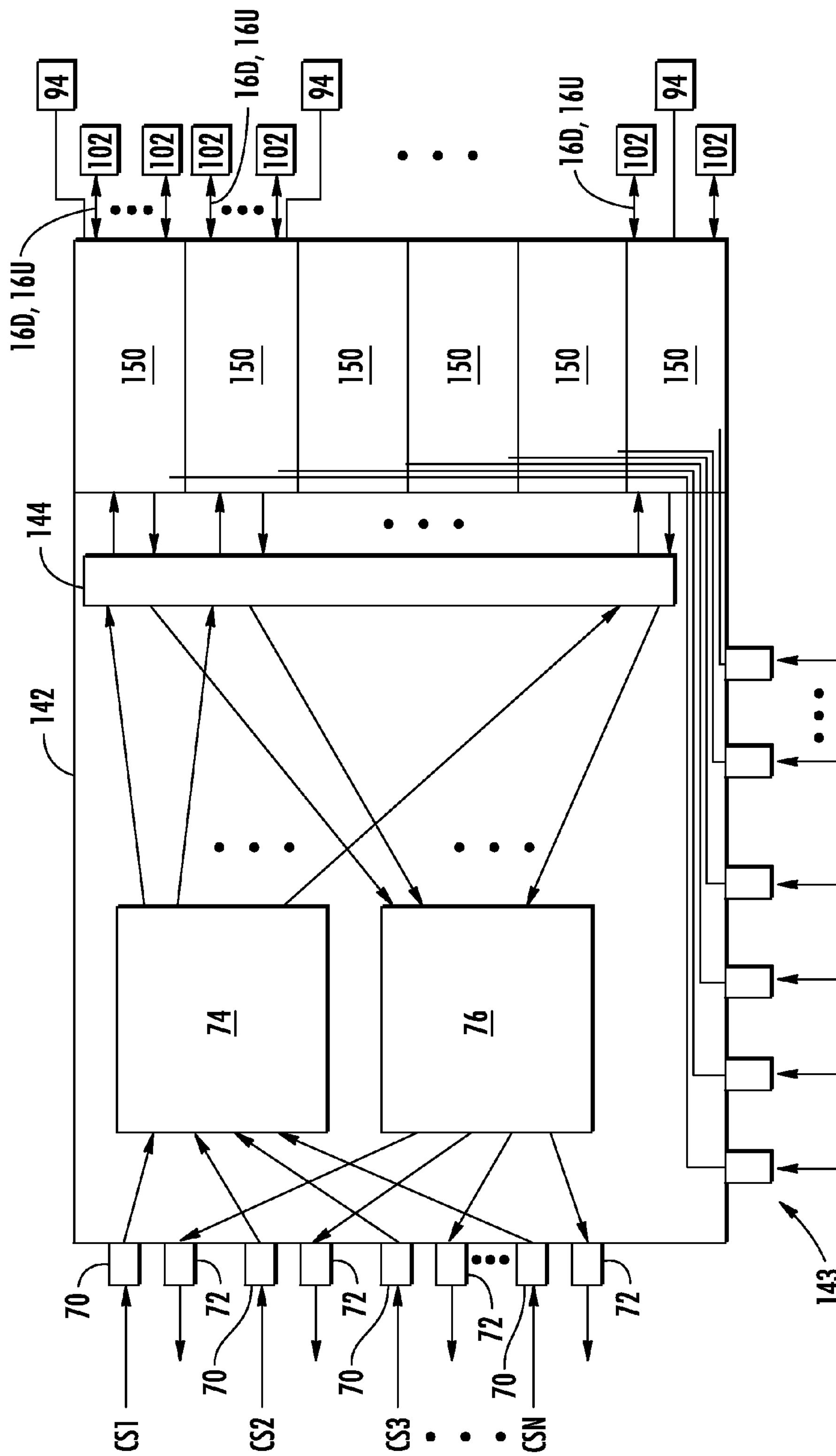
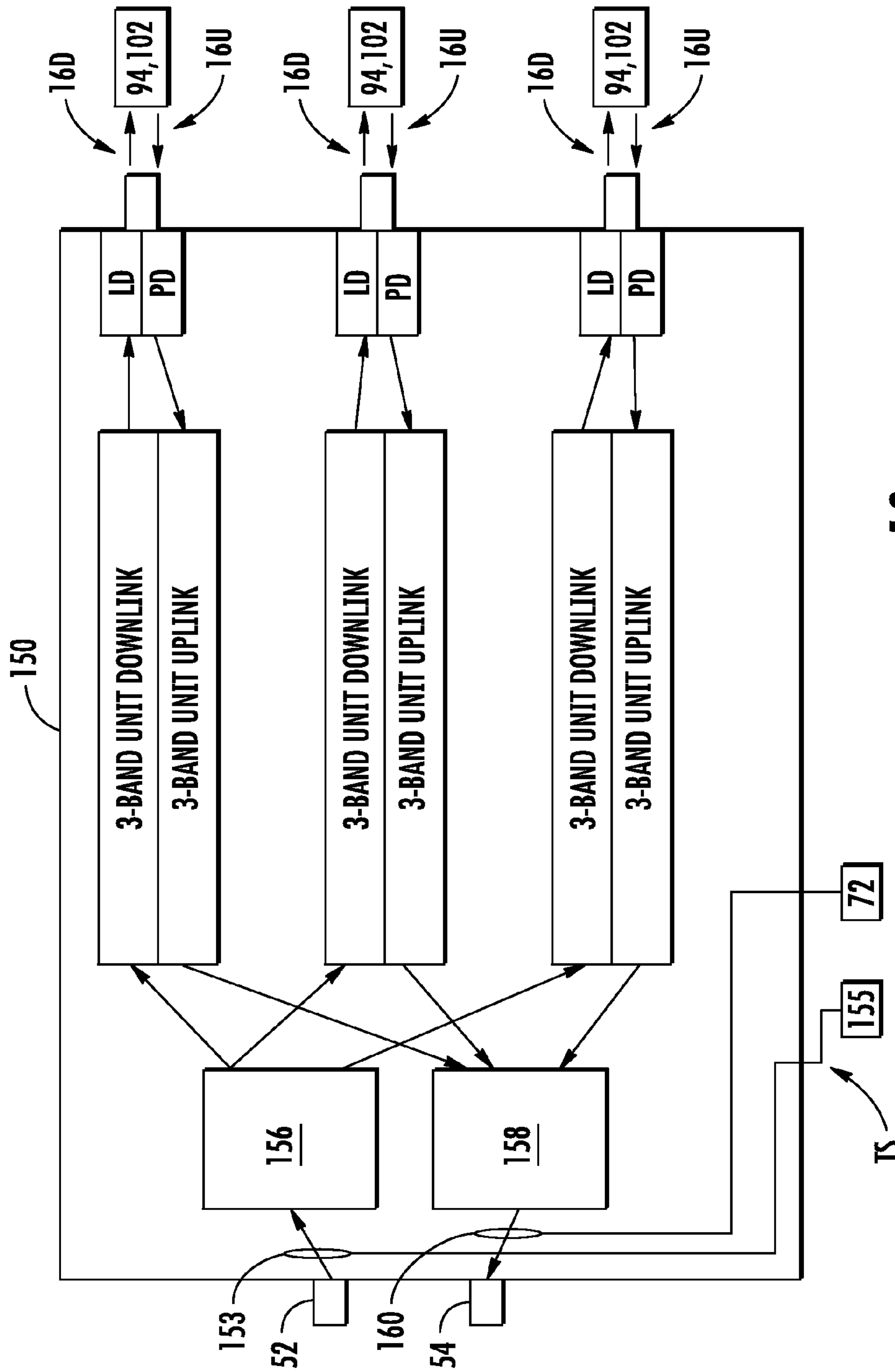

94
102
16D, 16U
150
144
142
74
76
TS1
TS2
TS3
TS4
TS5
TSN
143
70
72
CS1
CS2
CS3
CSN

FIG. 9



16D
94,102
16U
16D
94,102
16U
16D
94,102
16U
LD
PD
LD
PD
LD
PD
150
3-BAND UNIT DOWNLINK
3-BAND UNIT UPLINK
3-BAND UNIT DOWNLINK
3-BAND UNIT UPLINK
3-BAND UNIT DOWNLINK
3-BAND UNIT UPLINK
72
155
TS
156
158
153
152
160
154

FIG. 10

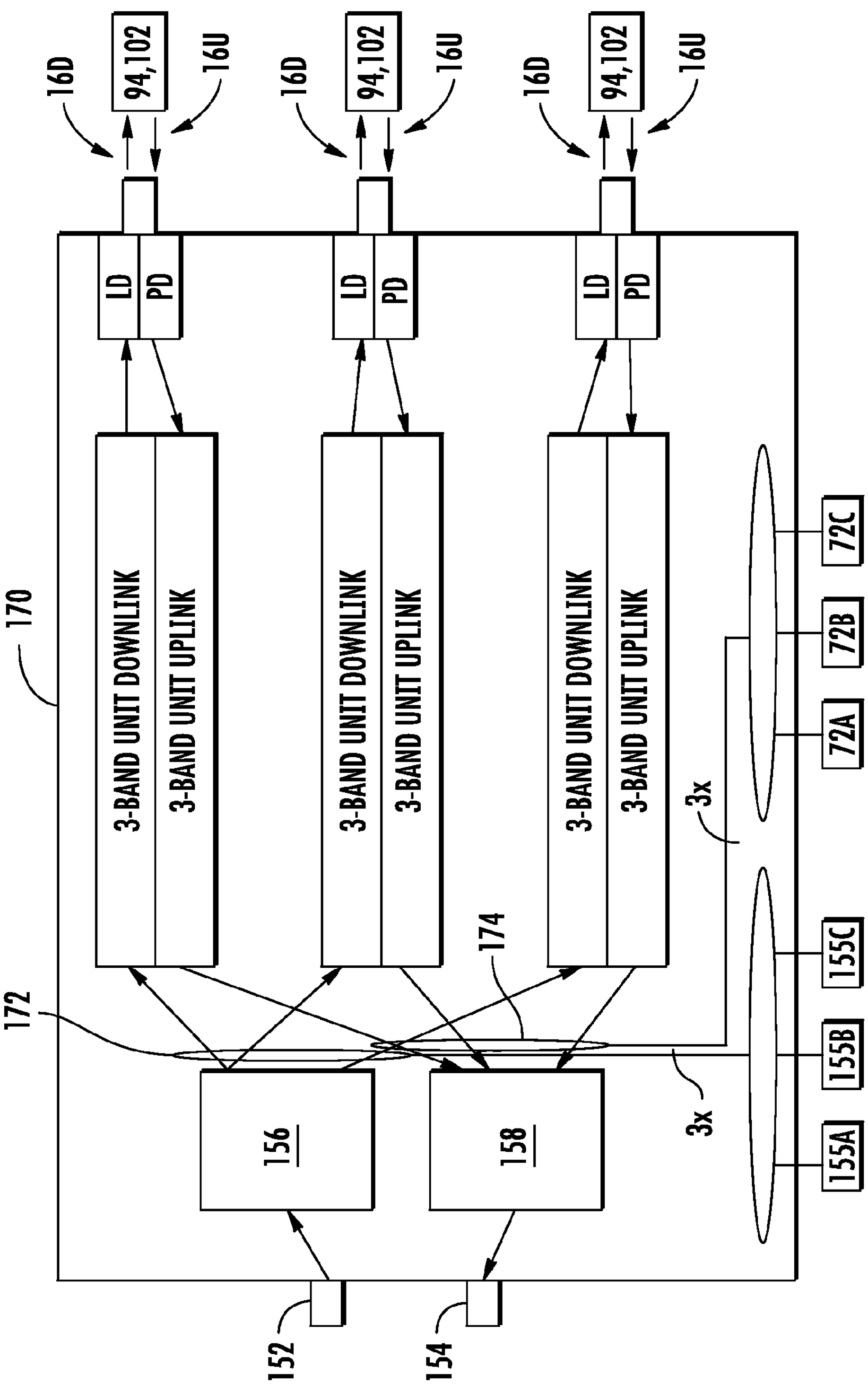

170
16D
94,102
16U
LD
PD
3-BAND UNIT DOWNLINK
3-BAND UNIT UPLINK
72A
72B
72C
3x
155A
155B
155C
172
174
156
158
152
154

FIG. 11

LOCALIZATION SERVICES IN OPTICAL FIBER-BASED DISTRIBUTED COMMUNICATIONS COMPONENTS AND SYSTEMS, AND RELATED METHODS

PRIORITY APPLICATION

This application is a continuation application of U.S. patent application Ser. No. 13/628,497 filed Sep. 27, 2012, now issued as U.S. Pat. No. 8,983,301, which claims priority to International Application No. PCT/US11/29895 filed Mar. 25, 2011, which claims the benefit of priority to U.S. Provisional Patent Application Ser. No. 61/319,659 filed Mar. 31, 2010, the contents of which are relied upon and incorporated herein by reference in their entireties.

BACKGROUND

Field of the Disclosure

The technology of the disclosure relates to optical fiber-based distributed communications systems for distributing radio-frequency (RF) signals over optical fiber to remote antenna units, and related control systems and methods.

Technical Background

Wireless communication is rapidly growing, with ever-increasing demands for high-speed mobile data communication. As an example, so-called “wireless fidelity” or “WiFi” systems and wireless local area networks (WLANs) are being deployed in many different types of areas (e.g., coffee shops, airports, libraries, etc.). Distributed communications systems communicate with wireless devices called “clients,” which must reside within the wireless range or “cell coverage area” in order to communicate with an access point device.

One approach to deploying a distributed communications system involves the use of radio frequency (RF) antenna coverage areas, also referred to as “antenna coverage areas.” Antenna coverage areas can have a radius in the range from a few meters up to twenty meters as an example. Combining a number of access point devices creates an array of antenna coverage areas. Because the antenna coverage areas each cover small areas, there are typically only a few users (clients) per antenna coverage area. This allows for minimizing the amount of bandwidth shared among the wireless system users. It may be desirable to provide antenna coverage areas in a building or other facility to provide distributed communications system access to clients within the building or facility. However, it may be desirable to employ optical fiber to distribute communication signals. Benefits of optical fiber include increased bandwidth.

One type of distributed communications system for creating antenna coverage areas, called “Radio-over-Fiber” or “RoF,” utilizes RF signals sent over optical fibers. Such systems can include a head-end station optically coupled to a plurality of remote antenna units that each provide antenna coverage areas. The remote antenna units can each include RF transceivers coupled to an antenna to transmit RF signals wirelessly, wherein the remote antenna units are coupled to the head-end station via optical fiber links. The RF transceivers in the remote antenna units are transparent to the RF signals. The remote antenna units convert incoming optical RF signals from the optical fiber link to electrical RF signals via optical-to-electrical (O/E) converters, which are then passed to the RF transceiver. The RF transceiver converts the electrical RF signals to electromagnetic signals via antennas coupled to the RF transceiver provided in the remote antenna units. The antennas also receive electromagnetic signals (i.e., electromagnetic radiation) from clients in the antenna coverage area and convert them to electrical RF signals (i.e., electrical RF signals in wire). The remote antenna units then convert the electrical RF signals to optical RF signals via electrical-to-optical (E/O) converters. The optical RF signals are then sent to the head-end station via the optical fiber link.

It may be desired to provide such optical fiber-based distributed communications systems indoors, such as inside a building or other facility, to provide indoor wireless communication for clients. Otherwise, wireless reception may be poor or not possible for wireless communication clients located inside the building. In this regard, the remote antenna units can be distributed throughout locations inside a building to extend wireless communication coverage throughout the building. Other services may be negatively affected or not possible due to the indoor environment. For example, it may be desired or required to provide localization services for a client, such as emergency 911 (E911) services as an example. If the client is located indoors, techniques such as global positioning services (GPSs) may not be possible to provide or determine the location of the client. Further, triangulation techniques from the outside network may not be able to determine the location of the client.

SUMMARY OF THE DETAILED DESCRIPTION

Embodiments disclosed in the detailed description include optical fiber-based distributed communications components and systems, and related methods to provide localization services for client devices. The localization services allow the providing and/or determination of the location of client devices in communication with a component or components of the optical fiber-based distributed communications system. The location of client devices can be provided and/or determined based on knowledge of the location of the component or components in the optical fiber-based distributed communications system in communication with the client device. In this scenario, the client device would be known to be within communication range of such component or components. This information can be used to determine or provide a more precise area of location of the client device. The optical fiber-based distributed communications components and systems, and related methods disclosed herein may be well-suited for indoor environments where other methods of providing and/or determining the location of client devices may be obstructed or not possible due to the indoor environment.

In this regard, in certain embodiments disclosed herein, distributed communications equipment is provided. The distributed communications equipment supports optical fiber-based distributed communications services. The distributed communications apparatus in this embodiment also supports providing a signal used for determining the location of client devices (also referred to herein as “tracking signal”) to remote antenna units (RAUs) configured to provide communications with client devices. The tracking signal may be generated by a tracking signal generator or pilot or beacon generator, as examples. The tracking signal is a unique signal that can be associated to a particular location or zone in the optical fiber-based distributed communications system. The location of the client device can be determined by correlating client device identification information with the ability of the client device to receive the tracking signal. The location of the client device can be determined by the distributed communications apparatus or other processing units coupled to the distributed communications apparatus over a network.

In this regard, the distributed communications apparatus includes at least one first downlink input configured to receive downlink electrical radio frequency (RF) communications signals. The distributed communications apparatus also includes at least one uplink output configured to receive and communicate uplink electrical RF communications signals from a communications uplink. The distributed communications apparatus also includes at least one optical interface (OI) configured to receive and convert the downlink electrical RF communications signals into downlink optical RF communications signals to be provided to at least one RAU, and receive and convert uplink optical RF communications signals from at least one RAU on the communications uplink into uplink electrical RF communications signals provided to the at least one uplink output. The distributed communications apparatus also includes at least one second downlink input configured to receive at least one electrical tracking signal. The at least one OI is further configured to receive and convert the at least one electrical tracking signal into at least one optical tracking signal to be provided to at least one RAU. The distributed communications apparatus may be configured to not split or combine the tracking signal so that the uniqueness of the correlation of the tracking signal to a particular component or components in the optical fiber-based distributed communications system is not lost and is retained. Related methods are also disclosed.

In other embodiments, a distributed communications apparatus is provided that is configured to support receiving client device identification information as uplink communication data from an RAU without receiving and providing a tracking signal to the RAU. By knowing and correlating the location of particular components within the optical fiber-based distributed communications system, the distributed communications apparatus and/or other systems coupled to the distributed communications apparatus over a network are able to determine and/or provide the location of the client device. The component or components with which the client device is in communication can be associated with identification information of the client device.

In this regard, the distributed communications apparatus includes at least one first downlink input configured to receive downlink electrical RF communications signals. The distributed communications apparatus also includes at least one uplink output configured to receive and communicate uplink electrical RF communications signals from a communications uplink. The distributed communications apparatus also includes an OI configured to receive and convert the downlink electrical RF communications signals into downlink optical RF communications signals to be provided to at least one RAU, and receive and convert uplink optical RF communications signals that include client device identification information from the at least one RAU on the communications uplink into uplink electrical RF communications signals provided to the at least one uplink output. To retain the distinctiveness of communications from the components in the optical fiber-based communications system for providing localization services, the distributed communications apparatuses may, for example, be configured to not split or combine uplink electrical RF communication signals from an RAU among the plurality of RAUs with uplink electrical RF communication signals from another RAU among the plurality of RAUs. Alternatively, the distributed communications apparatus may, for example, be configured to not split or combine the uplink electrical RF communication signals from the OI with uplink electrical RF communication signals from another OI.

Additional features and advantages will be set forth in the detailed description which follows, and in part will be readily apparent to those skilled in the art from that description or recognized by practicing the embodiments as described herein, including the detailed description that follows, the claims, as well as the appended drawings.

It is to be understood that both the foregoing general description and the following detailed description present embodiments, and are intended to provide an overview or framework for understanding the nature and character of the disclosure. The accompanying drawings are included to provide a further understanding, and are incorporated into and constitute a part of this specification. The drawings illustrate various embodiments, and together with the description serve to explain the principles and operation of the concepts disclosed.

BRIEF DESCRIPTION OF THE FIGURES

FIG. **1** is a schematic diagram of an exemplary optical fiber-based distributed communications system;

FIG. **2** is a partially schematic cut-away diagram of an exemplary building infrastructure in which an optical fiber-based distributed communications system is employed;

FIG. **3** is an exemplary schematic diagram of exemplary head-end equipment in the form of a head-end unit (HEU) deployed in the optical fiber-based distributed communications system of FIGS. **1** and **2**;

FIG. **4** is a schematic diagram of an exemplary optical fiber-based distributed communications system configured to communicate tracking signals to tracking remote antenna units (RAUs) to provide localization services for client devices;

FIG. **5**A is a schematic diagram of exemplary alternative head-end equipment configured to provide tracking signals to tracking RAUs to support providing localization services for client devices;

FIG. **5**B is a schematic diagram of other exemplary alternative head-end equipment configured to provide tracking signals to tracking RAUs to support providing localization services for client devices;

FIG. **6** is a schematic diagram of other exemplary alternative head-end equipment configured to provide communication signals to RAUs and tracking signals to tracking RAUs to support providing localization services for client devices;

FIG. **7** is a schematic diagram of the head-end equipment in FIG. **6** provided in an optical fiber-based distributed communications system in a building containing at least one tracking RAU per floor;

FIG. **8** is a schematic diagram of a fiber optic cable containing downlink and uplink optical fibers connected between an optical interface card(s) (OIC(s)) and RAUs, wherein an RAU and tracking RAU share a common antenna;

FIG. **9** is a schematic diagram of other exemplary alternative head-end equipment configured to provide communication signals to RAUs and tracking signals to tracking RAUs to support providing localization services for client devices;

FIG. **10** is a schematic diagram of an exemplary optical interface card (OIC) adapted and configured to support providing localization services for client devices on a per-OIC resolution in an optical fiber-based distributed communications system; and

FIG. **11** is a schematic diagram of an exemplary OIC adapted and configured to support providing localization services for client devices on a per-RAU resolution in an optical fiber-based distributed communications system.

DETAILED DESCRIPTION

Reference will now be made in detail to the embodiments, examples of which are illustrated in the accompanying drawings, in which some, but not all embodiments are shown. Indeed, the concepts may be embodied in many different forms and should not be construed as limiting herein; rather, these embodiments are provided so that this disclosure will satisfy applicable legal requirements. Whenever possible, like reference numbers will be used to refer to like components or parts.

Embodiments disclosed in the detailed description include optical fiber-based distributed communications components and systems, and related methods to provide localization services for client devices. The localization services allow the providing and/or determination of the location of client devices in communication with a component or components of the optical fiber-based distributed communications system. The location of client devices can be provided and/or determined based on knowledge of the location of the component or components in the optical fiber-based distributed communications system in communication with the client device. In this scenario, the client device would be known to be within communication range of such component or components. This information can be used to determine or provide a more precise area of location of the client device. The optical fiber-based distributed communications components and systems, and related methods disclosed herein may be well-suited for indoor environments where other methods of providing and/or determining the location of client devices may be obstructed or not possible due to the indoor environment.

Before discussing the exemplary components, systems, and methods of providing localization services in an optical fiber-based distributed communications system, which starts at FIG. **4**, an exemplary generalized optical fiber-based distributed communications is first described with regard to FIGS. **1**-**3**. In this regard, FIG. **1** is a schematic diagram of a generalized embodiment of an optical fiber-based distributed communications system. In this embodiment, the system is an optical fiber-based distributed communications system **10** that is configured to create one or more antenna coverage areas for establishing communications with wireless client devices located in the radio frequency (RF) range of the antenna coverage areas. In this regard, the optical fiber-based distributed communications system **10** includes head-end equipment, exemplified as a head-end unit or HEU **12**, one or more remote antenna units (RAUs) **14** and an optical fiber link **16** that optically couples the HEU **12** to the RAU **14**. The HEU **12** is configured to receive communications over downlink electrical RF signals **18**D from a source or sources, such as a network or carrier as examples, and provide such communications to the RAU **14**. The HEU **12** is also configured to return communications received from the RAU **14**, via uplink electrical RF signals **18**U, back to the source or sources. In this regard, in this embodiment, the optical fiber link **16** includes at least one downlink optical fiber **16**D to carry signals communicated from the HEU **12** to the RAU **14** and at least one uplink optical fiber **16**U to carry signals communicated from the RAU **14** back to the HEU **12**.

The optical fiber-based wireless system **10** has an antenna coverage area **20** that can be substantially centered about the RAU **14**. The antenna coverage area **20** of the RAU **14** forms an RF coverage area **21**. The HEU **12** is adapted to perform or to facilitate any one of a number of Radio-over-Fiber (RoF) applications, such as radio-frequency (RF) identification (RFID), wireless local-area network (WLAN) communication, or cellular phone service. Shown within the antenna coverage area **20** is a client device **24** in the form of a mobile device as an example, which may be a cellular telephone as an example. The client device **24** can be any device that is capable of receiving RF communication signals. The client device **24** includes an antenna **26** (e.g., a wireless card) adapted to receive and/or send electromagnetic RF signals.

With continuing reference to FIG. **1**, to communicate the electrical RF signals over the downlink optical fiber **16**D to the RAU **14**, to in turn be communicated to the client device **24** in the antenna coverage area **20** formed by the RAU **14**, the HEU **12** includes an electrical-to-optical (E/O) converter **28**. The E/O converter **28** converts the downlink electrical RF signals **18**D to downlink optical RF signals **22**D to be communicated over the downlink optical fiber **16**D. The RAU **14** includes an optical-to-electrical (O/E) converter **30** to convert received downlink optical RF signals **22**D back to electrical RF signals to be communicated wirelessly through an antenna **32** of the RAU **14** to client devices **24** located in the antenna coverage area **20**.

Similarly, the antenna **32** is also configured to receive wireless RF communications from client devices **24** in the antenna coverage area **20**. In this regard, the antenna **32** receives wireless RF communications from client devices **24** and communicates electrical RF signals representing the wireless RF communications to an E/O converter **34** in the RAU **14**. The E/O converter **34** converts the electrical RF signals into uplink optical RF signals **22**U to be communicated over the uplink optical fiber **14**U. An O/E converter **36** provided in the HEU **12** converts the uplink optical RF signals **22**U into uplink electrical RF signals, which can then be communicated as uplink electrical RF signals **18**U back to a network or other source. The HEU **12** in this embodiment is not able to distinguish the location of the client devices **24** in this embodiment. The client device **24** could be in the range of any antenna coverage area **20** formed by an RAU **14**.

To provide further exemplary illustration of how an optical fiber-based distributed communications system can be deployed indoors, FIG. **2** is a partially schematic cutaway diagram of a building infrastructure **40** employing the optical fiber-based distributed communications system **10** of FIG. **1**. The building infrastructure **40** generally represents any type of building in which the optical fiber-based distributed communications system **10** can be deployed. As previously discussed with regard to FIG. **1**, the optical fiber-based distributed communications system **10** incorporates the HEU **12** to provide various types of communication services to coverage areas within the building infrastructure **40**, as an example. For example, as discussed in more detail below, the optical fiber-based distributed communications system **10** in this embodiment is configured to receive wireless radio-frequency (RF) signals and convert the RF signals into Radio-over-Fiber (RoF) signals to be communicated over the optical fiber link **16** to the RAUs **14**. The optical fiber-based distributed communications system **10** in this embodiment can be, for example, an indoor distributed antenna system (IDAS) to provide wireless service inside the building infrastructure **40**. These wireless signals can include, but are not limited to, cellular service, wireless services such as RFID tracking, Wireless Fidelity (WiFi), local area network (LAN), and combinations thereof, as examples.

With continuing reference to FIG. **2**, the building infrastructure **40** includes a first (ground) floor **42**, a second floor **44**, and a third floor **46**. The floors **42**, **44**, **46** are serviced by the HEU **12** through a main distribution frame **48**, to provide antenna coverage areas **50** in the building infrastructure **40**. Only the ceilings of the floors **42**, **44**, **46** are shown in FIG. **2** for simplicity of illustration. In the example embodiment, a main cable **52** has a number of different sections that facilitate the placement of a large number of RAUs **14** in the building infrastructure **40**. Each RAU **14** in turn services its own coverage area in the antenna coverage areas **50**. The main cable **52** can include, for example, a riser section **54** that carries all of the downlink and uplink optical fibers **16**D, **16**U to and from the HEU **12**. The main cable **52** can include one or more multi-cable (MC) connectors adapted to connect select downlink and uplink optical fibers **16**D, **16**U, along with an electrical power line, to a number of optical fiber cables **56**.

The main cable **52** enables multiple optical fiber cables **56** to be distributed throughout the building infrastructure **40** (e.g., fixed to the ceilings or other support surfaces of each floor **42**, **44**, **46**) to provide the antenna coverage areas **50** for the first, second and third floors **42**, **44** and **46**. In an example embodiment, the HEU **12** is located within the building infrastructure **40** (e.g., in a closet or control room), while in another example embodiment the HEU **12** may be located outside of the building infrastructure **40** at a remote location. A base transceiver station (BTS) **58**, which may be provided by a second party such as a cellular service provider, is connected to the HEU **12**, and can be co-located or located remotely from the HEU **12**. A BTS is any station or source that provides an input signal to the HEU **12** and can receive a return signal from the HEU **12**. In a typical cellular system, for example, a plurality of BTSs are deployed at a plurality of remote locations to provide wireless telephone coverage. Each BTS serves a corresponding cell and when a mobile station enters the cell, the BTS communicates with the mobile station. Each BTS can include at least one radio transceiver for enabling communication with one or more subscriber units operating within the associated cell.

To provide further detail on the components of the exemplary HEU **12** provided in the optical fiber-based distributed communications system **10** of FIGS. **1** and **2**, FIG. **3** is provided. FIG. **3** is a schematic diagram of the HEU **12** to provide further detail. As illustrated therein, the HEU **12** in this embodiment includes a head-end controller (HEC) **60** that manages the functions of the HEU **12** components and communicates with external devices via interfaces, such as a RS-232 port **62**, a Universal Serial Bus (USB) port **64**, and an Ethernet port **68**, as examples. The HEU **12** can be connected to a plurality of BTSs, transceivers, and the like via inputs **70**, which may be BTS inputs or other inputs, and outputs **72**, which may be BTS outputs or other outputs The inputs **70** are downlink connections and the outputs **72** are uplink connections, which can be provided in single connectors or together in a duplex connector. Each input **70** is connected to a downlink BTS interface card (BIC) **74** located in the HEU **12**, and each output **72** is connected to an uplink BIC **76** also located in the HEU **12**. The downlink BIC **74** is configured to receive incoming or downlink RF signals from the inputs **70** and split the downlink RF signals into copies to be communicated to the RAUs **14**, as illustrated in FIG. **2**. The uplink BIC **76** is configured to receive and combine outgoing or uplink RF signals from the RAUs **14** and split the uplink RF signals into individual inputs **70** as a return communication path.

The downlink BIC **74** is connected to a midplane interface card **78** panel in this embodiment. The uplink BIC **76** is also connected to the midplane interface card **78**. The downlink BIC **74** and uplink BIC **76** can be provided in printed circuit boards (PCBs) that include connectors that can plug directly into the midplane interface card **78**. The midplane interface card **78** is in electrical communication with a plurality of optical interface cards (OICs) **80**, which provide an optical to electrical communication interface and vice versa between the RAUs **14** via the downlink and uplink optical fibers **16**D, **16**U and the downlink BIC **74** and uplink BIC **76**. The OICs **80** include the E/O converter **28** in FIG. **1** that converts electrical RF signals from the downlink BIC **74** to optical RF signals, which are then communicated over the downlink optical fibers **16**D to the RAUs **14** and then to client devices. The OICs **80** also include the O/E converter **36** in FIG. **1** that converts optical RF signals communicated from the RAUs **14** over the uplink optical fibers **16**U to the HEU **12** and then to the outputs **72**.

The OICs **80** in this embodiment support up to three (3) RAUs **14** each. The OICs **80** can also be provided in a PCB that includes a connector that can plug directly into the midplane interface card **78** to couple the links in the OICs **80** to the midplane interface card **78**. The OICs **80** may consist of one or multiple optical interface cards (OICs). In this manner, the HEU **12** is scalable to support up to thirty-six (36) RAUs **14** in this embodiment since the HEU **12** can support up to twelve (12) OICs **80**. If fewer than thirty-six (36) RAUs **14** are to be supported by the HEU **12**, fewer than twelve OICs **80** can be included in the HEU **12** and plugged into the midplane interface card **78**. One OIC **80** is provided for every three (3) RAUs **14** supported by the HEU **12** in this embodiment. OICs **80** can also be added to the HEU **12** and connected to the midplane interface card **78** if additional RAUs **14** are desired to be supported beyond an initial configuration. A head-end unit controller (HEU) **60** can also be provided that is configured to be able to communicate with the DL-BIC **74**, the UL-BIC **76**, and the OICs **80** to provide various functions, including configurations of amplifiers and attenuators provided therein.

It may be desired to provide localization services in the optical fiber-based distributed communications system **10** illustrated in FIGS. **1** and **2**, as an example. For example, it may be desired to know or determine the location of client devices **24**. Localization services may be desired or required to provide certain services, such as emergency 911 (E911) services in the case of a cellular client device. Localization services may require a certain percentage of client devices **24** to be locatable within a given distance to comply with requirements. For example, it may be desired or required by E911 services to be able to locate a given percentage of all client device users within one hundred (100) feet (ft.) as an example. Localization services may be desired or required for other types of wireless clients other than cellular clients as well. If the client device **24** is located inside the building infrastructure **40** and establishes communication with the HEU **12**, it can be determined that the client device **24** is located within at least the distance between the farthest RAU **14** located from the HEU **12**. However, it may not be possible to determine the location of the client device **24** with greater specificity and resolution. For example, in indoor environments, global positioning services (GPSs) provided in the client devices **24** may be inoperable to report a location.

If it could be determined to which particular components in the optical fiber-based communication system **10** a client device **24** establishes communications, this information could be used to determine the location of a client device **24**. The client device **24** would be known to be within communication range of such component. This information coupled with knowing the location of the HEU **12** can be used to determine or provide a more precise area of location of the client device **24**. In essence, the RAUs **14** provide another layer of location determination in addition to the location of the HEU **12**. Cellular networks, for example, provide methods of determining location.

In this regard, certain embodiments are disclosed herein to provide an optical fiber-based distributed communications system that supports localization services for client devices located within antenna coverage areas created by RAUs. In certain embodiments disclosed herein, the client device is configured to include client device identification information as uplink communication data to the RAU and to the HEU and network connected thereto without receiving a tracking signal or other signal configured to provide localization services. For example, Global System for Mobile Communications (GSM) network compatible client devices are configured to automatically initiate providing client device identification information over the network. The locations of the RAUs in the system are also configured and known in the HEU. By knowing and correlating the particular RAU in which the client device established communication, the HEU is able to determine and/or provide the location of the client device as being within the antenna coverage area formed by the particular RAU. The correlation of client device identification information from the client device with the location of the RAU is retained when communicated to the HEU and is not lost by being combined, such as by splitters or containers, with communications from other RAUs.

In other embodiments, a signal used for determining the location of client devices (also referred to herein as "tracking signal"), and which may also be referred to as a pilot signal, beacon signal, or pilot beacon signal, is distributed by an HEU to at least one of the RAUs in an optical fiber-based distributed communications system. The tracking signal may be generated by a tracking signal generator or pilot or beacon generator as examples. The tracking signal is a unique signal that can be associated with a particular location or zone in the optical fiber-based distributed communications system. For example, in a code division multiple access (CDMA) network, cell identification is included in a channel separate from communications traffic that can be used as a tracking signal. In this manner, the tracking signal is radiated through the RAU to be communicated to client devices within range of the antenna coverage area formed by the RAU. When the client device wirelessly receives the tracking signal, the client device communicates its identification information and identification of the tracking signal to an RAU to be communicated back to the HEU. The HEU can provide this information to a network or carrier. In this manner, the client device identification information and identification of the tracking signal can be associated with the location of a particular RAU that received and transmitted the tracking signal in the optical fiber-based distributed communications system to provide or determine a location of the client device.

In this regard, FIG. **4** illustrates a schematic diagram of an exemplary optical fiber-based distributed communications system **90** that is configured to communicate tracking signals TS**1**-TS**4** from an HEU **91** to certain tracking RAUs **94**A-**94**D to provide localization services. The tracking RAUs **94**A-**94**D can contain the same components and configuration as the RAUs **14**. Thus, this configuration of the optical fiber-based distributed communications system **90** employs a tracking signal provided on downlinks to the RAUs **94**A-**94**D to provide localization services. The difference is that the tracking RAUs **94**A-**94**D are communicatively coupled to channels or links provided by the HEU **91** that are dedicated to carry a tracking signal. Each tracking signal TS**1**-TS**4** has a unique identification from the other tracking signals TS**1**-TS**4** in this embodiment. The tracking RAUs **94**A-**94**D selected to receive tracking signals TS**1**-TS**4** can be strategically located within different tracking zones **96** in a building **98** or other infrastructure. For example, FIG. **4** illustrates four tracking zones **96**A-**96**D. Each tracking zone **96**A-**96**D may represent a floor within the building **98** wherein a tracking RAU **94**A-**94**D is located on each floor. In this embodiment, the tracking signal is not used for communications, and the client devices can receive the tracking signal from the tracking RAUs **94**A-**94**D over a greater distance than communications. Thus, when client devices are located within range of a particular tracking RAU **94**A-**94**D, the client device will receive the particular tracking signal TS**1**-TS**4** designated for the floor communicated to the tracking RAU **94**A-**94**D. The client device can then communicate client device identification information regarding the received tracking signal TS**1**-TS**4** back to the HEU **91** and over a network **100**. Thus, the particular floor in which the client device is located can be provided or determined. Note that although the example of tracking illustrates four (4) tracking zones **96**A-**96**D, the disclosure herein is not limited to providing a particular number of tracking zones or tracking RAUs placed in the tracking zones to receive and wireless transmit a tracking signal to client devices.

With continuing reference to FIG. **4**, other communications RAUs **102**A-**102**D that are not configured to receive and wirelessly transmit the tracking signals TS**1**-TS**4** are also provided in the optical fiber-based distributed communications system **90**. In this embodiment, these communications RAUs **102**A-**102**D form antenna coverage areas in each of the tracking zones **96**A-**96**D that are not associated with providing tracking signals or location services. The communications RAUs **102**A-**102**D are like the RAUs **14** previously described and illustrated in FIGS. **1** and **2** that provide downlink network communications to client devices in range of the antenna coverage areas and receive wireless communications from the client devices to communicate uplink communication data back to the HEU **91** and over the network **100**. More than one communications RAU **102**A-**102**D may be provided in a given zone **96**A-**96**D to provide communications between client devices inside the building **98** and the network **100**.

As also illustrated in FIG. **4**, the tracking RAUs **94**A-**94**D could also be configured to transmit downlink communication data to client devices in addition to the tracking signals TS**1**-TS**4**. For example, tracking RAU **94**D is configured to receive both tracking signal TS**3** and downlink communication data from the HEU **91** and transmit both to client devices in range of the tracking RAU **94**D. When the client device in range of the tracking RAU **94**D receives the tracking signal and the downlink communication data, the client device can transmit client device identification information and uplink communication data back to the HEU **91** and over the network **100**. The tracking RAU **94**D may be configured to receive uplink communication data from a client device, or may be configured to only transmit the tracking signal and downlink communication data to a client device. In the latter case, a second communications RAU **102**D located in proximity to the tracking RAU **94**D may be configured to receive the client device identification information and uplink communication data from the client device to provide to the HEU **91** and the network **100**.

As previously discussed and illustrated in FIG. **3**, the HEU **12** includes the downlink BIC **74** that combines downlink electrical RF signals received from the inputs **70**. Further, the HEU **12** combines uplink electrical RF signals received from the OICs **80** carrying uplink information received by the RAUs **14** and then splits the combined uplink electrical RF signals out into individual outputs **72**. Thus, if the HEU **12** in FIG. **3** were employed as the HEU **91** in FIG. **4** to provide the tracking signals TS**1**-TS**4** to provide localization services, the uniqueness of the tracking signals TS**1**-TS**4** would be lost and thus could not be used to associate the location of client devices to particular RAUs **14** to provide localization services. This is because the downlink BIC **74** would split the tracking signals TS**1**-TS**4** into copies and communicate the copies of the tracking signals TS**1**-TS**4** to each of the RAUs **14** instead of particular RAUs **14**. Thus, client devices could receive tracking signals TS**1**-TS**4** in any of the tracking zones **96**A-**96**D in FIG. **4**, as an example.

Embodiments disclosed herein can include modified HEUs that provide exemplary solutions to uniquely provide tracking signals on downlinks to certain designated tracking RAUs without copies of the tracking signals being communicated to each RAU. The tracking signals are not combined with the RF communication signals for communication traffic. The client devices can receive the tracking signal from individual tracking RAUs independent of RF communication signals and the uniqueness of associating particular client device identification information received from a client device to a particular tracking RAU is not lost, and thus the location of the client devices relative to tracking RAUs can be determined and/or provided.

In this regard, FIG. **5**A illustrates a schematic diagram of an exemplary embodiment of an alternative HEU **110** that is configured to provide tracking signals to RAUs **14** without splitting the tracking signals into copies that are distributed to multiple RAUs **14**. The HEU **110** can be provided as the HEU **91** in FIG. **4**. Thus, the association of a tracking signal to a particular RAU **14** is not lost as is the case in the HEU **12** of FIG. **3**, where the downlink BIC **74** splits the downlink electrical RF signals into copies provided to each RAU **14**. The HEU **110** does include some common components to the HEU **12** illustrated in FIG. **3**. Where common components are included, common element numbers are used in FIG. **5**A.

With continuing reference to FIG. **5**A, the downlink BIC **74** of the HEU **12** of FIG. **3** has been removed so that tracking signals TS**1**-TS**3** provided as inputs to the inputs **70** do not get split into copies provided to multiple tracking RAUs **94**. The tracking signals TS**1**-TS**3** are provided to dedicated tracking RAUs **94** so that a client device receiving a given tracking signal TS**1**-TS**3** is known to be within the antenna coverage area of the tracking RAU **94** dedicated to receive a given tracking signal TS**1**-TS**3**. The HEU **110** is also configured to receive communication signals CS (FIG. **6**) to be provided to communications RAUs **102** that are not used to receive and communicate the tracking signals TS**1**-TS**3**, as also illustrated in FIG. **4**. In response to receipt of a tracking signal TS**1**-TS**3** from a tracking RAU **94**, a client device can return its client device identification information over the uplink optical fibers **16**U to the HEU **110**. In this regard, it is known that the client device is within the antenna coverage area of the tracking RAU **94** receiving communications from the client device. Thus, this information can be retained by the HEC **60** in the HEU **110** and/or provided to the network **100** (FIG. **4**) to determine and/or provide the location of the client device as being within the antenna coverage area of the tracking RAU **94**.

In the example HEU **110** of FIG. **5**A, three tracking signals TS**1**-TS**3** are provided as inputs to three inputs **70**; however, more or less tracking signals could be provided. The electrical RF signals received in the inputs **70** may be provided to a signal power leveling module **112** to level the power between different signals provided to different inputs **70**, if desired. However, the tracking signals TS**1**-TS**3** are not combined or split in the signal power leveling module **112**. A connector panel **114** may also be provided in the HEU **110** to receive the electrical RF signals from the inputs **70** and provide a connection to OICs **80** to convert the electrical RF signals to optical RF signals, as previously discussed. The signal power leveling module **112** and OICs **80** may be disposed, for example, in printed circuit board (PCB) cards that can be plugged into connectors disposed in the connector panel **114** to connect the outputs and inputs of the signal power leveling module **112** to the inputs and outputs, respectively, of the OICs **80**. The connector panel **114** may also be a PCB card that contains circuitry or other components.

FIG. **5**B illustrates a schematic diagram of an exemplary embodiment of an alternative HEU **110'** that is configured to provide tracking signals to RAUs **14** also without splitting the tracking signals into copies that are distributed to multiple RAUs **14**. Thus, the association of a tracking signal to a particular RAU **14** is not lost as is the case in the HEU **12** of FIG. **3**. The HEU **110'** does include some common components to the HEU **12** illustrated in FIG. **3**. Where common components are included, common element numbers are used in FIG. **5**B.

With continuing reference to FIG. **5**B, radio interface modules (RIMs) **113**(**1**)-**113**(N) are provided that receive the downlink electrical RF signals from the inputs **70** to provide RF communications services. The notations "1-N" indicate that any number of the RIMs, 1-N, may be provided. Each RIM **113**(**1**)-**113**(N) may support RF communication services for given frequencies or frequency ranges or bands. The downlink electrical RF signals are then combined in a radio distribution card or cards (RDC) **115** to be provided to the OIMs **80** and the RAUs **94**, as previously discussed. The RIMs **113**(**1**)-**113**(N) are configured to receive and process downlink electrical RF signals from the inputs **70** prior to optical conversion into downlink optical RF signals.

Each RIM **113**(**1**)-**113**(N) can be designed to support a particular type of radio source or range of radio sources (i.e., frequencies) to provide flexibility in configuring the HEU **110'** to support the desired radio sources. For example, one RIM **113** may be configured to support the Personal Communication Services (PCS) radio band. Another RIM **113** may be configured to support the Long Term Evolution (LTE) **700** radio band. In this example, by inclusion of these RIMs **113**, the HEU **110'** would be configured to support and distribute RF signals on both PCS and LTE **700** radio bands. RIMs **113** may be provided in the HEU **110'** that support any other radio bands desired, including but not limited to PCS, LTE, CELL, GSM, CDMA, CDMA2000, TDMA, AWS, iDEN (e.g., 800 MHz, 900 MHz, and 1.5 GHz), Enhanced Data GSM Environment, (EDGE), Evolution-Data Optimized (EV-DO), 1×RTT (i.e., CDMA2000 1× (IS-2000)), High Speed Packet Access (HSPA), 3GGP1, 3GGP2, and

Cellular Digital Packet Data (CDPD). More specific examples include, but are not limited to, radio bands between 400-2700 MHz including but not limited to 700 MHz (LTE), 698-716 MHz, 728-757 MHz, 776-787 MHz, 806-824 MHz, 824-849 MHz (US Cellular), 851-869 MHz, 869-894 MHz (US Cellular), 880-915 MHz (EU R), 925-960 MHz (TTE), 1930-1990 MHz (US PCS), 2110-2155 MHz (US AWS), 925-960 MHz (GSM 900), 1710-1755 MHz, 1850-1915 MHz, 1805-1880 (GSM 1800), 1920-1995 MHz, and 2110-2170 MHz (GSM 2100).

With continuing reference to FIG. **5**B, note that the tracking signals TS**1**-TSN are not provided to the RDC **115** where the tracking signals TS**1**-TSN are combined and split, but rather are provided to dedicated tracking RAUs **94** so that a client device receiving a given tracking signal TS**1**-TSN is known to be within the antenna coverage area of the tracking RAU **94** dedicated to receive a given tracking signal TS**1**-TSN. In this regard, HEU **110'** is also configured to receive communication signals CS (FIG. **6**) to be provided to communications RAUs **102** that are not used to receive and communicate the tracking signals TS**1**-TSN. In response to receipt of a tracking signal TS**1**-TSN from a tracking RAU **94**, a client device can return its client device identification information over the uplink optical fibers **16**U to the HEU **110'**. In this regard, it is known that the client device is within the antenna coverage area of the tracking RAU **94** receiving communications from the client device. Thus, this information can be retained by the HEC **60'** in the HEU **110'** and/or provided to the network **100** (FIG. **4**) to determine and/or provide the location of the client device as being within the antenna coverage area of the tracking RAU **94**. In the HEU **110** of FIG. **5**A, both the downlink BIC **74** and uplink BIC **76** from the HEU **12** of FIG. **3** were removed from both the tracking signal TS and communication signal CS communication paths through the HEU **110** to the RAUs **94**, **102**. However, it is not necessary to remove the downlink BIC **74** and the uplink BIC **76** from the communication signals CS communication paths. In the HEU **110'** of FIG. **5**B, the tracking signals TS**1**-TSN were not combined and split with downlink RF signals in the RDC **115**. In this regard, FIG. **6** illustrates a schematic diagram of an exemplary alternative HEU **120** that is configured in a hybrid configuration. FIG. **7** illustrates the functionality of the HEU **120** provided in two separate HEUs **120**A, **120**B, each dedicated to either handle tracking signals TS or communication signals CS. The HEUs **120**A, **120**B are provided in an optical fiber-based distributed communications system **130** wherein RAUs **94**, **102** are distributed in different floors of a building **132** similar to the optical fiber-based distributed communications system **10** in FIG. **2**. One tracking RAU **94**(**1**)-**94**(N) is provided for each floor **134**(**1**)-**134**(N) in the building **132**.

With reference back to FIG. **6**, some communication paths are dedicated for tracking signals TS**1**-TSN and other communication paths are dedicated for communication signals CS**1**-CSN. In this regard, separate connection panels **122**A, **122**B are provided for each type of communication path for the HEUs **120**A, **120**B. The downlink BIC **74** and uplink BIC **76** are employed in the communication signal CS**1**-CSN communication paths in the HEU **120**A to split copies of the communication signals CS**1**-CSN to be provided to the communications RAUs **102**, as described previously and illustrated in the HEU **12** of FIG. **3**. Alternatively in FIG. **6**, RIMs may be employed in lieu of the downlink BIC **74** and uplink BIC **76**. In this example, the downlink BIC **74** and uplink BIC **76** are not employed in the tracking signal TS**1**-TSN communication paths in the HEU **120**B such that copies of the tracking signals TS**1**-TSN are not provided to multiple tracking RAUs **94**, otherwise the ability to associate the tracking signals TS**1**-TSN to a particular tracking RAU **94** would be lost in this embodiment.

The tracking RAUs **94** and communications RAUs **102** may be provided as separate RAUs or may be configured to share components. For example, a tracking RAU **94** may be co-located with a communications RAU **102** and share the same antenna. In this regard, FIG. **8** illustrates an fiber optic cable **138** comprised of downlink optical fibers **16**D and uplink optical fibers **16**U connected to one or more OICs **80**. In this embodiment, a tracking RAU **94** is provided that is co-located with a communications RAU **102**, as illustrated in FIG. **8**. In this regard, the tracking RAU **94** and communications RAU **102** may be configured to share some common components. For example, in this embodiment, the tracking RAU **94** and co-located communications RAU **102** share a common, single antenna **140**. A power combiner **141** is provided to combine electrical RF signals transmitted from both the tracking RAU **94** and communications RAU **102** for downlink communications and to split uplink communication signals transmitted from client devices to the antenna **140** destined for the tracking RAU **94** and the communications RAU **102**. Alternatively, the uplink communication signals may not be split between the tracking RAU **94** and the communications RAU **102**. Both the tracking RAU **94** and communications RAU **102** may receive all uplink communication signals from client devices in range of the antenna **140** and communicate the signals back to the HEUs **120**A, **120**B. The HEUs **120**A, **120**B can employ filters or other processing techniques to separate the uplink communication signals from the uplink client device identification information, if needed or desired.

FIG. **9** illustrates a schematic diagram of an exemplary embodiment of an HEU **142** with a port configuration to separate tracking signals inputs from communication signal inputs. In this regard, separate ports **143** are provided to receive tracking signals TS**1**-TSN from tracking signal generators to provide to tracking RAUs **94**. The tracking signals TS**1**-TSN bypass the downlink BIC **74**, the uplink BIC **76**, and a connection panel **144** and are connected directly to ports in OICs **150**. This can allow one HEU **142** to be provided to distribute both the tracking signals TS**1**-TSN and communication signals CS**1**-CSN instead of providing two separate HEUs, like provided in FIGS. **6** and **7**. In this embodiment, the tracking signals TS**1**-TSN are combined with communication signals CS**1**-CSN in an OIC **80** that is configured to receive both signals. The combined tracking signals TS**1**-TSN and communication signals CS**1**-CSN are communicated to the tracking RAU **94** and the communications RAU **102**. This implementation does not have the location resolution on a per RAU basis that would be provided if the tracking signals TS**1**-TSN were not combined in the OICs **150** with the communication signals CS**1**-CSN. The location resolution is per OIC **150** instead of per RAU **94**, **102** in this embodiment. However, separate HEUs are not required in this embodiment. Further, the power signal levels between the tracking signals TS**1**-TSN and the communication signals CS**1**-CSN can be varied relative to each other.

FIG. **10** illustrates an example of an OIC **150** that may be provided as part of the OIC **80** in FIG. **9** to provide one solution to prevent the tracking signal received by the OIC **150** from being sent to all communications RAUs **102** supported by the OIC **150** so that tracking information is not lost. In this embodiment, an OIC **150** is provided and is comprised of a single PCB to support up to three (3) RAUs in this embodiment; however, this configuration is not required and the number of supported RAUs is not limiting. For example, two OICs **150** coupled be provide in a single optical interface module (OIM) to support up to six (6) RAUs in this embodiment. The OIC **150** is illustrated with one downlink port **152** and one uplink port **154**. The downlink port **152** provides the combined downlink electrical RF signals from the downlink BIC **74** to the OIC **150** to convert such downlink electrical RF signals to downlink optical RF signals to communicate over the downlink optical fibers **16**D to communications RAUs **102**, as illustrated in FIG. **9**. A splitter **156** splits the downlink RF signals into multiple copies to be provided to each of the communications RAUs **102** supported by the OIC **150**. The uplink port **154** receives uplink electrical RF signals that are converted from uplink optical signals received from the communications RAUs **102**. The uplink electrical RF signals are combined via a combiner **158** and passed to the uplink port **154** to be communicated to the uplink BIC **76**.

In the OIC **150** of FIG. **10**, the OIC **150** has been modified and adapted to be used to allow a tracking signal to be communicated to all communications RAUs **102** supported by the OIC **150** to provide a per-OIC location resolution. In this manner, a completely new design for the OIC **150** is not required. In this regard, a downlink tap **153** is provided in the OIC **150** to allow a tracking signal generator **155** to bypass the downlink BIC **74** to provide a tracking signal TS directly to the OIC **150**. The tracking signal TS is communicated through the splitter **156** such that a copy of the tracking signal TS is provided to each RAU **94**, **102** supported by the OIC **150**. Thus, the location information provided by distribution of the tracking signal TS will only allow location determination on the resolution of the OIC **150** and not on a per RAU basis since the tracking signal is provided to all RAUs **94**, **102** supported by the OIC **150**. A downlink communication signal can also be communicated to the OIC **150** through the downlink port **152** to also provide communication signals to the RAUs **94**, **102**. The tracking signal TS and downlink communication signals will be split by the splitter **156** into copies provided to each RAU **94**, **102**.

Similarly, an uplink tap **160** is provided to bypass the uplink BIC **76** provided in an HEU so that client device identification information received from the RAUs **94**, **102** is not combined with other uplink communication signals from other HEUs. The client device identification information received from the RAUs **94**, **102** is combined by the combiner **158**; thus, location information provided by distribution of the tracking signal TS in this embodiment will only allow location determination on the resolution of the OIC **150** and not on a per RAU basis.

FIG. **11** illustrates an alternative OIC **170** that has also been modified and adapted to allow a tracking signal from a tracking signal generator and returned client device identification information from RAUs to bypass the downlink BIC **74** and the uplink BIC **76** like provided in the OIC **150** in FIG. **10**. However, in the OIC **170** of FIG. **11**, location determination can be provided on a per RAU basis instead of a per OIC basis. This is because downlink taps **172** for receiving tracking signals and uplink taps **174** for receipt of returned client device identification information are provided separately for each RAU **94**, **102** supported by the OIC **170**. In this embodiment, because the OIC **170** supports three (3) RAUs **94**, **102**, three (3) downlink taps **172** and three (3) uplink taps **174** are provided. The downlink taps **172** and uplink taps **174** are provided after the splitter **156** and combiner **158** so that the tracking signal is not copied to multiple RAUs **94**, **102**, and so that returned client device identification information from the RAUs **94**, **102** is not combined. In this embodiment, the OIC **170** can receive up to three (3) tracking signal generators **155**A-**155**C to provide unique tracking signals to each RAU **94**, **102**. Likewise, the client device identification information returned by the RAUs **94**, **102** to the OIC **170** can be individually provided to three (3) separate outputs **72**A-**72**C.

Further, as used herein, it is intended that terms “fiber optic cables” and/or “optical fibers” include all types of single mode and multi-mode light waveguides, including one or more optical fibers that may be upcoated, colored, buffered, ribbonized and/or have other organizing or protective structure in a cable such as one or more tubes, strength members, jackets or the like. Likewise, other types of suitable optical fibers include bend-insensitive optical fibers, or any other expedient of a medium for transmitting light signals. An example of a bend-insensitive, or bend resistant, optical fiber is ClearCurve® Multimode fiber commercially available from Corning Incorporated. Suitable fibers of this type are disclosed, for example, in U.S. Patent Application Publication Nos. 2008/0166094 and 2009/0169163.

Many modifications and other embodiments of the embodiments set forth herein will come to mind to one skilled in the art to which the embodiments pertain having the benefit of the teachings presented in the foregoing descriptions and the associated drawings. These modifications include, but are not limited to, whether a tracking signal is provided, whether downlink and/or uplink BICs are included, whether tracking signal inputs are provided in the same distributed communications apparatus as downlink inputs, the number and type of OICs and RAUs provided in the distributed communications system, etc. Therefore, it is to be understood that the description and claims are not to be limited to the specific embodiments disclosed and that modifications and other embodiments are intended to be included within the scope of the appended claims. It is intended that the embodiments cover the modifications and variations of the embodiments provided they come within the scope of the appended claims and their equivalents. Although specific terms are employed herein, they are used in a generic and descriptive sense only and not for purposes of limitation.

What is claimed is:

1. A method for providing localization services in a distributed communications system, comprising:

configuring at least one distinct location zone in the distributed communications system, wherein the at least one distinct location zone comprises a tracking remote antenna unit (RAU);

providing at least one tracking signal to the tracking RAU in the at least one distinct location zone, wherein the at least one tracking signal carries an identification of the at least one tracking signal that identifies the at least one distinct location zone;

broadcasting the at least one tracking signal from the tracking RAU;

receiving an uplink radio frequency (RF) communications signal from a client device located in the at least one distinct location zone, wherein the uplink RF communications signal comprises client device identification information and the identification of the at least one tracking signal; and

locating the client device based on the client device identification information and the identification of the at least one tracking signal.

2. The method of claim 1, further comprising generating the at least one tracking signal from a tracking signal generator or a pilot generator or a beacon generator.

3. The method of claim 1, further comprising receiving the uplink RF communications signal from the client device without providing the at least one tracking signal to the tracking RAU in the at least one distinct location zone, wherein the uplink RF communications signal comprises the client device identification information.

4. The method of claim 1, further comprising not splitting or combining the at least one tracking signal.

5. The method of claim 1, further comprising communicatively coupling the tracking RAU to channels dedicated to carry the at least one tracking signal.

6. The method of claim 5, further comprising receiving the client device identification information from the client device after communicating the at least one tracking signal.

7. The method of claim 5, further comprising receiving the client device identification information from the client device without communicating the at least one tracking signal.

8. A method for configuring a distributed communications system to provide localization services, comprising:
- configuring at least one distinct location zone in the distributed communications system, wherein the at least one distinct location zone comprises a plurality of remote antenna units (RAUs);
- identifying and configuring a tracking RAU among the plurality of RAUs;
- providing a distributed communications apparatus in the distributed communications system, further comprising:
  - configuring at least one first downlink input to receive downlink radio frequency (RF) communications signals, wherein the downlink RF communications signals are configured to carry downlink communication data;
  - configuring at least one second downlink input to receive at least one tracking signal identifying the at least one distinct location zone; and
  - configuring at least one uplink output to receive and communicate uplink RF communications signals from a communications uplink, wherein the uplink RF communications signals carry client device identification information and an identification of the at least one tracking signal identifying the at least one distinct location zone; and
- configuring the tracking RAU in the at least one distinct location zone to receive and transmit the at least one tracking signal identifying the at least one distinct location zone.

9. The method of claim 8, further comprising configuring the tracking RAU to transmit the at least one tracking signal and the downlink communication data carried in the downlink RF communications signals.

10. The method of claim 8, further comprising associating the client device identification information to a location of the tracking RAU.

11. The method of claim 10, further comprising not splitting or combining the uplink RF communications signals received from the tracking RAU with the uplink RF communications signals received from another RAU among the plurality of RAUs.

12. The method of claim 8, further comprising communicatively coupling the tracking RAU to channels dedicated to carry the at least one tracking signal.

13. The method of claim 12, further comprising receiving the client device identification information from a client device after communicating the at least one tracking signal.

14. The method of claim 12, further comprising receiving the client device identification information from a client device without communicating the at least one tracking signal.

15. A distributed communications system for providing localization services, comprising:
- at least one distinct location zone in the distributed communications system, wherein the at least one distinct location zone comprises a tracking remote antenna unit (RAU); and
- a distributed communications apparatus configured to:
  - provide at least one tracking signal to the tracking RAU in the at least one distinct location zone, wherein the at least one tracking signal carries an identification of the at least one tracking signal that identifies the at least one distinct location zone;
  - broadcast the at least one tracking signal from the tracking RAU;
  - receive an uplink radio frequency (RF) communications signal from a client device located in the at least one distinct location zone, wherein the uplink RF communications signal comprises client device identification information and the identification of the at least one tracking signal; and
  - locate the client device based on the client device identification information and the identification of the at least one tracking signal.

16. The distributed communications system of claim 15, wherein the distributed communications apparatus is further configured to generate the at least one tracking signal from a tracking signal generator or a pilot generator or a beacon generator.

17. The distributed communications system of claim 15, wherein the distributed communications apparatus is further configured to receive the uplink RF communications signal from the client device without providing the at least one tracking signal to the tracking RAU in the at least one distinct location zone, wherein the uplink RF communications signal comprises the client device identification information.

18. The distributed communications system of claim 15, wherein the distributed communications apparatus is further configured not to split or combine the at least one tracking signal.

19. The distributed communications system of claim 15, wherein the tracking RAU is communicatively coupled to channels dedicated to carry the at least one tracking signal.

20. The distributed communications system of claim 19, wherein the distributed communications apparatus is further configured to receive the client device identification information from the client device after communicating the at least one tracking signal.

21. The distributed communications system of claim 19, wherein the distributed communications apparatus is further configured to receive the client device identification information from the client device without communicating the at least one tracking signal.

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